早稲田大学大学院情報生産システム研究科

博士論文概要

論文題目

Study on the Route Planning Algorithms using Q Value-based Dynamic Programming

申請者
MAINALI, Manoj Kanta

情報生産システム工学専攻
進化型計算システム研究

2011年 6月

One of the main functions of the navigation systems is to provide the drivers of cars with the optimal route guidance to the destination. In transportation networks, traffic problems such as traffic congestions, traffic accidents etc. occur frequently which leads to the increase in the traveling time and also disrupts the flow of traffic. To improve the efficiency of transportation networks, the real time traffic information are collected and distributed as a part of Intelligent Transportation Systems (ITS). Therefore, the navigation systems are capable of receiving the collected information and efficiently update the previous optimal route based on the received information to provide the route guidance.

The algorithms such as Dijkstra or A* are often used to find the optimal route. However, the drawback of the conventional algorithms is that they can not adapt efficiently to the changes in the traveling times of road networks because they need to re-calculate the route from scratch, which is usually inefficient because only the part of the routes needs to be updated. Because the changes in the traveling time of road sections occur frequently, it is required to develop a new method that adapts efficiently to the frequent changes.

Usually, a route with the minimum traveling time or distance is considered in the route guidance, but the surveys have shown that users prefer to travel on near optimal routes, where the route selection is influenced by several factors such as route attributes, user characteristics etc. Actually, it is necessary to consider whether the user feels comfortable or not for the route recommendation when traveling on the recommended route. Therefore, to provide better route guidances, it is necessary to find the routes that are preferred by the users rather than the ones with the minimum traveling time.

On the other hand, the route guidance is often considered as the route search from the origin to destination. However, it is needed in practical cases to consider the restrictions such that certain locations are not included or several intermediate destinations must be visited before arriving at the final destination. Therefore, it is necessary to develop the route planning method that can handle such restrictions in the route search.

While the traffic information collected are used not only by the navigation systems to provide the dynamic route guidances, but also in some other applications such as traffic signal control, traffic density prediction etc.

However, actually there exist many missing data in the collected information due to various reasons such as detector failures, communication problems etc. In order to maximize the usability of the collected traffic information it is also necessary to fill the missing data with their estimates.

In chapter 1, the research background, motivation, objectives and outline of the thesis are described. The objectives of this research are to develop the methods for route planning considering the topics discussed above and to develop the techniques to estimate the missing traffic volumes. The route planning problems are studied in from chapters 2 to 6 and the estimation of missing traffic volumes is studied in chapter 7.

In chapter 2, a route search algorithm based on dynamic programming called Q Value-based Dynamic Programming (QDP) is proposed. In the proposed method, Q values are calculated by solving simultaneous non-linear equations to determine the optimal route and its optimal traveling time to the destination. The feature of the proposed method is the re-usability of the Q values to efficiently find the new optimal route when the traveling time of road sections changes. The simulation results show that the proposed method can efficiently adapt to the changes in the traveling time of road sections.

Chapter 3 describes a hierarchical model to improve the computational efficiency of QDP. In the hierarchical model, a road network is divided into several subnetworks and the high-level network is built with origin, destination, border intersections and the optimal route and its optimal traveling time between them and the high-level network is used for the route search along with the original road network. In addition, a method for the efficient re-routing is proposed when the traveling time changes in which a partial optimization of the route obtained from the high-level network is studied. The hierarchical QDP is compared with the non-hierarchical QDP and it is shown from simulation results that the hierarchical QDP is efficient when doing a large number of route searches. The simulations also show that the proposed re-routing gives the route with the traveling time close to the optimal traveling time.

Chapter 4 proposes a high-level network pruning method where the border intersections to include in the high-level network are selected using Genetic Algorithm (GA) in order to further improve the computational efficiency of the hierarchical QDP. However, the pruning leads to the loss of accuracy of the routes. Therefore, the pruning is formulated as a multi-objective problem which minimizes the traveling time and the route search time. The simulation results show that the pruning approach improves the computational efficiency with small loss of accuracy.

In chapter 5, an extension of QDP is proposed to find the user preferred routes considering multiple criteria. In the proposed method, criteria such as turn at intersections, type of road sections and traffic lights are considered in addition to the traveling time. It is supposed that the users' preferences for the criteria are given and based on them appropriate cost values for the criteria such as turn at intersections etc. are determined using GA. The proposed method is evaluated considering different users' preferences and it is shown that it can find the routes based on the preferences.

Chapter 6 studies the route search with restrictions. Restriction of excluding certain locations from the route and the restriction of including several intermediate destinations in the route are considered. Because the former restriction can be easily handled, this chapter focuses on the latter restriction. In the proposed approach, firstly the optimal routes and its optimal traveling times are calculated among origin, destination and intermediate destinations. Then, the visiting order of the intermediate destinations is optimized using the population based RasID-D method to minimize the total traveling time. Finally, the route to the destination via intermediate destinations is determined based on the obtained visiting orders. The proposed method is evaluated by the result of visiting order optimization and its efficiency is shown.

In chapter 7, a GA based method that estimates the missing traffic volumes is proposed based on the concept of traffic volume balance. The feature of the proposed method is to estimate multiple missing traffic volumes simultaneously using the available traffic volumes information. The proposed method is evaluated using the traffic volume data generated by a traffic simulator and it is shown that the proposed method gives the estimates close to the actual traffic volumes.

Chapter 8 concludes the thesis by describing the achievements of the proposed methods.